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STORAGE FOR WATER QUALITY CONTROL MANGUM PROJECT SALT FORK OF RED RIVER

Public Health Service
Dallas, Texas

March 1963

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WATER QUALITY CONTROL
MANGUM PROJECT
SALT FORK OF
RED RIVER

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U.S. DEPARTMENT OF HEALTH, EDUCATION, AND WELFARE
Public Health Service, Region VII
Dallas, Texas

In Cooperation with the

U.S. DEPARTMENT OF THE INTERIOR
Bureau of Reclamation
Oklahoma City Development Office--Oklahoma

MARCH 1963

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WATER QUALITY CONTROL
MANGUM PROJECT
SALT FORK OF
RED RIVER

U.S. DEPARTMENT OF HEALTH, EDUCATION, AND WELFARE
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Division of Water Supply and Pollution Control
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I. INTRODUCTION

Authority

In a letter dated July 24, 1962, the Bureau of Reclamation, Oklahoma City Development Office, stated "Our field draft of the Mangum Project feasibility report, . . . will include storage of Salt Fork flows at a point west of Mangum, Oklahoma. Your water quality control report should be completed as soon as possible."

This study has been made in accordance with the above request and Section 2 (b) of the Federal Water Pollution Control Act (Public Law 84-660) as amended.

Purpose and Scope

This report presents water requirements for water quality control purposes to the year 2012 in the Salt Fork of the Red River basin together with an estimate of annual benefits ascribable to storage allocated at the proposed Mangum Project site for this purpose.

Acknowledgments

The assistance and cooperation of many persons and agencies are gratefully acknowledged. Appreciation is especially expressed to the following:

Oklahoma State Department of Health, Oklahoma City, Oklahoma

Oklahoma Water Resources Board, Oklahoma City, Oklahoma

Bureau of Reclamation, Oklahoma City, Oklahoma

Chamber of Commerce, Altus and Mangum, Oklahoma

Local government officials, Altus and Mangum, Oklahoma

II. SUMMARY AND CONCLUSIONS

Summary

1. The Mangum Project will be located on the South Fork of Red River in Greer County five miles west of Mangum, Oklahoma.

2. The study area comprises Greer and Jackson Counties in southwestern Oklahoma.

3. Water to be impounded in Mangum Reservoir is of unsuitable quality for municipal and industrial uses due to the high sulfates and total dissolved solids content; however, it could be used successfully for irrigation on certain types of soil. Water from Mangum Reservoir will be blended with water from Lake Altus on the North Fork of the Red River to improve its quality. The resulting mixture will not be of the quality required for municipal and industrial uses. The water will be used as a supplemental supply for 47,000 irrigated acres in the study area.

4. The two major municipalities in the study area are Altus (1960 population--21,225) which obtains its water supply from Lake Altus and Mangum (1960 population--3,950) which uses wells as a source of water supply.

5. Mangum's wastes receive secondary treatment prior to discharge to the South Fork of Red River downstream from the Project site. Altus' wastes will be treated by sewage lagoons with the final effluent discharging to Bitter Creek, a tributary to the Salt Fork, downstream from the Mangum sewage plant outfall.

Conclusions

1. Population of the study area was 40,180 in 1960 and is expected to reach 57,000 by the year 2012.

2. Municipal water needs for the study area, projected to the year 2012, are 7.7 mgd (million gallons per day) and will be supplied by ground water and surface supplies other than the proposed Mangum Project.

3. Flow regulation for water quality control is needed to protect legitimate uses of the Salt Fork in the reach from Mangum to the confluence of Bitter Creek below Altus. This need, projected to the year 2012, could be met by releases from storage at the proposed Mangum Reservoir site averaging 1 mgd (1,120 acre-feet annually).

4. Based on the cost of constructing and operating a lagoon which would result in no discharge to the stream due to evaporation and percolation as the most reasonable alternative for averting unsatisfactory stream quality in the absence of flow regulation, the average annual benefit of storage and release of water for quality control purposes is $3,800.

III. DESCRIPTION OF PROJECT

Location

Salt Fork rises in Armstrong County, Texas, and flows generally southeast through the extreme southwestern part of Oklahoma into the Red River. As shown in Figure 1, Mangum Reservoir will be constructed in Greer County five miles west of Mangum at about mile 42 of the Salt Fork.

Streamflow

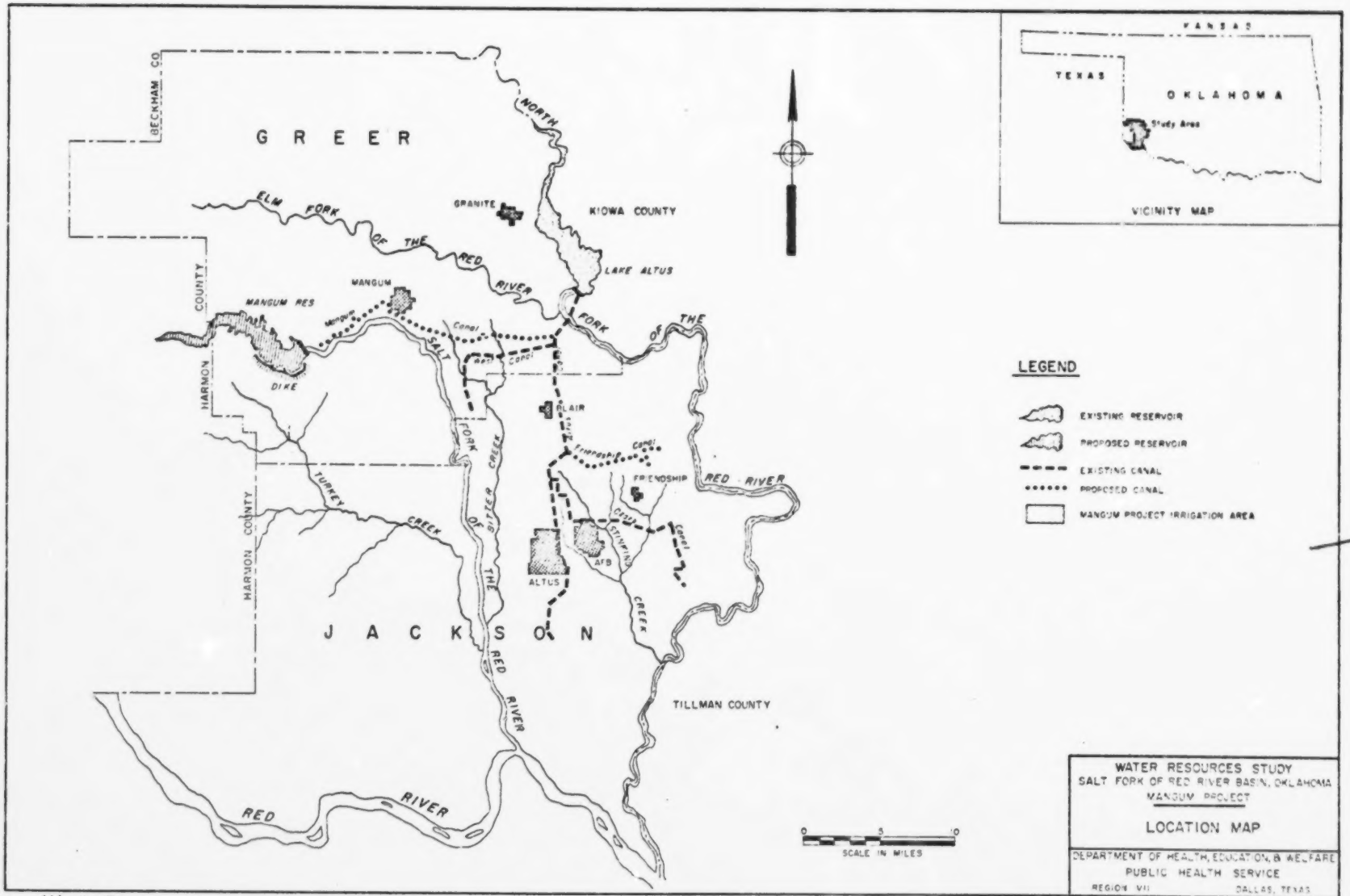
The flow of Salt Fork is mostly from surface runoff, with minor contribution of ground water seepage from gypsum formations. The U. S. Geological Survey maintains a gaging station on the Salt Fork south of Mangum. The Bureau of Reclamation has provided data on drainage, irrigation releases, and spills for the reservoir at Mangum. These 34-year month-by-month irrigation data ending in 1959 were used as one of the bases for this study. The proposed method of operation will result in little, if any, spill from the reservoir.

The drainage area of the proposed reservoir will be reduced as the result of construction of the proposed Lake Creek Reservoir to be located on the upper reach of Salt Fork in Donley County, Texas. The Mangum Project watershed will total approximately 980 square miles below the proposed Lake Creek Dam site confined to Collingsworth County and a small portion of Donley County in Texas. The remaining drainage area, approximately 620 square miles, lies in Oklahoma between the Mangum Dam site and the confluence with the Red River in Greer and Jackson Counties. Turkey Creek and Bitter Creek are the major tributaries to the Salt Fork below Mangum. These two creeks account for the majority of the flow downstream from the Mangum site.

Water Quality

Concentrations of total dissolved solids and sulfates in the Salt Fork exceed recommended limits in the Public Health Service Drinking Water Standards--1962. A summary of analyses of samples taken from the Salt Fork at Mangum by the U. S. Geological Survey is shown in Table III-1.

Neither the waters from Mangum Reservoir nor the blended Lake Altus and Mangum Reservoir water will meet the Public Health Service Drinking Water Standards. Municipal and industrial water needs in the study area are expected to be met from sources other than the Mangum Project.



III-1-A

FIGURE 1

Table III-1

Water Quality--Salt Fork
(Period of record--12/59 to 4/61)

	Concentrations in Parts Per Million			
	Total Dissolved Solids	Total Hardness	Chlorides	Sulfates
Arith. Average	2,454	1,445	202	1,383
Maximum	2,880	1,610	220	1,750
Minimum	1,950	1,320	188	975

Pertinent Data

The dam will be of the earthfill type. Maximum capacity will be obtained by constructing dikes along the southern perimeter as shown in Figure 1. Storage allocations are shown in Table III-2.

Table III-2

Storage Allocation

Elevation (ft., msl)		Volumes (acre-feet)	
Flood Control Pool	1,649.65	Flood Control	60,000
Conservation Pool	1,640.0	Conservation Storage	113,571
Inactive Pool	1,584.1	Sediment	69,453
Streambed	1,550.0	Inactive Pool	56
Top of Dam	1,680.0	Total	243,080

Topography

The proposed Project area (irrigation) lies between the North Fork and the Salt Fork of the Red River as shown in Figure 1. The topography is generally rolling. The irrigation area lies in a flat valley with two small meandering streams, one flowing into the North Fork and the other into the Salt Fork of the Red River.

IV. DESCRIPTION OF STUDY AREA

The area considered to affect water quality of Salt Fork downstream from the proposed project consists of Greer and Jackson Counties, shown on Figure 1 as the study area. In general, the topography of the study area is similar to that of the irrigation project area.

The mean temperature in the study area varies from 41° F for January to 85° F for July with an average daily temperature of 63° F. The growing season is approximately 225 days.

Agriculture is the leading basic industry of the area in terms of income and employment. Crops presently under cultivation are cotton, wheat, alfalfa, sorghum, and some sugar beets.

Major municipalities in the study area are Mangum in Greer County and Altus in Jackson County.

V. THE ECONOMY

Present

Employment

Agriculture is a major employer with 35.2 percent of the labor force in 1940, and 19.4 percent of the labor force in 1960. Service industries increased from 50.2 percent to 64.2 percent of the labor force in the same 20-year period. The total number employed in the study area remained fairly constant from 1940 to 1960. Employment data are illustrated in Table V-1.

Table V-1

Study Area Employment--1940 to 1960

	Labor Force					
	1940		1950		1960	
Industry	Number	Percent	Number	Percent	Number	Percent
Agriculture	4,355	35.2	3,745	35.2	2,110	19.4
Forestry and Fisheries	4	0.1	3	0.1	--	0.0
Mining	83	0.7	102	0.9	75	0.7
Construction	255	2.0	582	5.4	737	6.8
Manufacturing	387	3.1	478	4.4	498	4.6
Service*	6,213	50.2	5,224	49.4	6,953	64.2
Unemployed	1,063	8.7	495	4.6	465	4.3
Labor Force	12,360	100.0	10,629	100.0	10,838	100.0
Employed	11,297	91.3	10,134	95.4	10,373	95.7

*Service employment includes all noncommodity producing industries (wholesale and retail trade, services, government, and others).

Income

Personal income for the study area has increased from $18,521,000 in 1940 to $60,824,000 (1954 dollars) in 1960 as shown in Table V-2. During this same period, per capita income increased over 300 percent in the study area as compared to about 250 percent increase in Oklahoma.

Table V-2

Personal Income for Study Area from 1940 to 1960
(1954 Dollars)

Year	Total Income ($1,000's)	Per Capita Income
1940	18,521	$ 496
1945	30,505	940
1950	28,299	855
1955	41,410	1,440
1960	60,824	1,575

Agriculture

Agriculture is the largest income producing industry of the study area. In 1959, total agricultural output was valued at $18,180,000 as shown in Table V-3. Irrigation in Jackson and Greer Counties has increased from 318 acres in 1944 to 42,209 acres in 1959. Much of this increase was a result of the Altus irrigation project. This project was placed in operation during the late 1940's and now furnishes partial water supply for 47,000 acres.

Table V-3

Agricultural Activity for Study Area
From 1944 to 1959

(All Values in 1,000's of 1954 $'s)

Year	No. of Farms	Cropland Harvested (acres)	Value of all Crops Sold	Value of Livestock & Livestock Products	Value of All Farm Products
1944	3,318	467,312	9,070	3,995	13,065
1949	2,926	428,910	17,085	2,680	19,765
1954	2,598	419,454	13,355	2,620	15,975
1959	1,983	274,735	12,840	5,340	18,180

Irrigated land in 1959 accounted for 15 percent of the cropland harvested. Although crop production accounted for 70 percent of the value of agricultural products in 1959, livestock production is becoming more important. (See Table V-3.) Higher productivity of agricultural labor and technological improvements have enabled agriculture to increase output between 1954 and 1959 while the farm labor force and acres of cropland harvested were declining.

Mining

Petroleum and natural gas are the leading minerals produced in the study area. The present value of minerals production is about equal to the 1953 value with a peak of $2,157,000 being reached in 1955 as shown in Table V-4. The 1960 value of $907,500 represents 0.1 percent of the value of mineral production in Oklahoma.

Table V-4

Value of Mineral Production for Study Area
From 1953 to 1960
(1,000's of 1954 dollars)

Year	Total
1953	986
1954	1,679
1955	2,157
1956	1,474
1957	1,617
1958	957
1959	965
1960	907

Manufacturing

As shown in Table V-5, the value added by manufacturing for 1958 was about $2,000,000. Food and kindred products, transportation equipment, and printing and publishing accounted for 80 percent of the manufacturing employment in 1960.

Table V-5

Manufacturing Activity for the Study Area
From 1947 to 1958

Year	Value Added by Manufacturing (1,000's of 1954 Dollars)
1947	1,650
1954	1,317
1958	2,010

Population

The population of the study area has remained fairly constant in the past 50 years with a peak of 49,000 in the 1930's. There has been a steady shifting of population to urban areas during the last 10 years. The population trend is summarized in Table V-6 and illustrated in Figure 2.

Table V-6

Historical Population for Study Area from 1910 to 1960

Year	Total	Urban
1910	40,186	8,490
1920	37,977	7,932
1930	49,192	13,244
1940	37,258	12,786
1950	31,831	14,006
1960	38,613	25,175

Future

There will be a continued increase in the total economic development of the study area. Agriculture is expected to be the largest income-producing industry.

Increased irrigation and other technological innovations should increase the value of agricultural output resulting in economic growth of the area. The agricultural labor force is expected to decline slightly as new technology improvements and increased productivity of agricultural labor are put into practice.

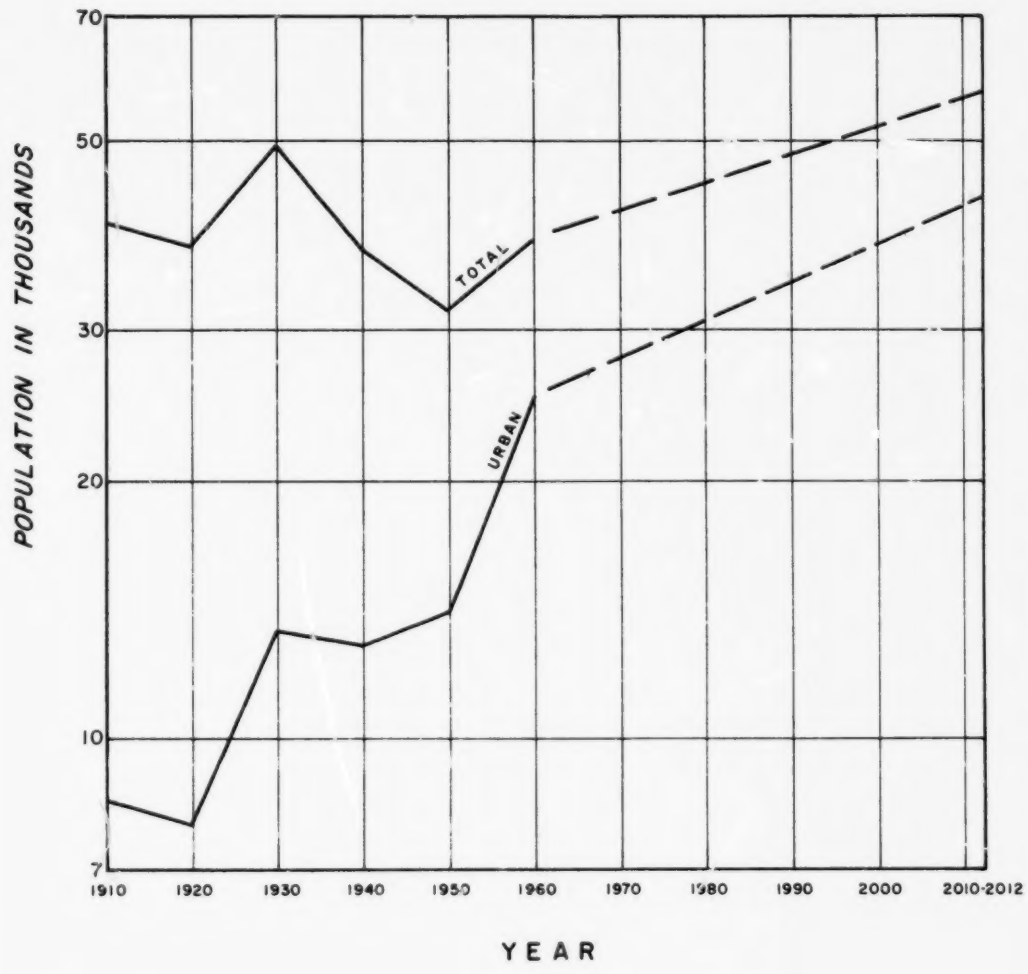
The role of manufacturing is anticipated to be more important to the study area's economy. As agriculture increases its output, an increase of food and kindred processing in the area is expected.

Mineral extraction should remain at its approximate present level as improved methods of secondary petroleum recovery are achieved and new areas of mineral production are discovered.

Population Projections

Based on the study area's economic predictions and past trends, the population is expected to increase 33 percent from 38,613 in 1960 to 57,000 in 2012. Figure 2 shows the projected population from the year 1960 to 2012.

V5



WATER RESOURCES STUDY
SALT FORK OF RED RIVER BASIN, OKLAHOMA
MANGUM PROJECT

POPULATION TRENDS

DEPARTMENT OF HEALTH, EDUCATION & WELFARE
PUBLIC HEALTH SERVICE
REGION VII DALLAS, TEXAS

FIGURE 2

VI. WATER USE

Use of water almost inevitably results in a change in its condition--usually degradation. An examination of expected water use and resulting waste production provides a basis for estimating quality changes and forecasting streamflow regulation requirements.

Municipal Use

Municipal water use will be centered at Altus and Mangum. Municipal water needs are projected as a function of 2012 daily per capita use and population expected to be served by public water supply systems.

The unit municipal water use for the year 2012 is expected to be 185 gallons per capita. Estimated municipal water requirements in the year 2012 will total 7.7 mgd (million gallons per day).

Irrigation Use

Irrigation has played an important role in the study area's economy and its importance is expected to be undiminished. There are presently 47,000 acres of irrigated land in the Altus-Luggert Irrigation District. The proposed Mangum Project will be a supplemental source and will reduce but not eliminate water shortages for this acreage. It is expected that with the addition of the Mangum Project, surface water irrigation will require 91,300 acre-feet/year (or an annual average of 81.5 mgd). The Mangum Project will supply 37,000 acre-feet/year (or an annual average of 35.9 mgd) by 2012.

Recreation and Other Legitimate Use

Water-oriented recreation is an activity of consequential worth in the study area as displayed at Lake Altus. An increasing need for reaches of water of suitable quality for recreational use and propagation of fish and aquatic life will result from the proposed project. This need will focus attention on stream reaches adjacent to (downstream from) the proposed Mangum Reservoir.

Additional Water Needs

Municipal water needs for the community of Mangum will be met by drilling additional wells. Future water needs for the city of Altus (including Altus Air Force Base) will be served from sources other than the proposed Mangum Project.

Water Quality Control Requirements

Under the provisions of the Federal Water Pollution Control Act, Public Law 84-660, as amended, consideration must be given to the inclusion of storage for regulation of streamflow to control water quality in any reservoir being planned by a Federal agency. Storage and release of this water is not to be provided as a substitute for adequate treatment of wastes at their sources.

Water quality analysis is based on broad parameters which are currently available for evaluation of future stream conditions. Total dissolved solids (TDS) is employed to characterize the effects of stable pollutants (those constituents which are not utilized or reduced by stream environment) such as chloride salts. Dissolved oxygen content is applied as a measure of unstable pollutants (those constituents which decay and act on, or are acted on by, the stream environment) as appraised by biochemical oxygen demand (BOD).

While water to be stored in the proposed Mangum Project is of unsuitable quality for use in reducing total dissolved solids in Salt Fork to an acceptable level, its quality will be appropriate for controlling dissolved oxygen balance. Dissolved oxygen is a significant factor in maintenance of an environment proper for propagation of fish and aquatic life.

Determination of storage requirements for water quality control is based upon the effects of adequately treated waste releases, resulting from expected economic expansion and population growth, upon receiving stream regimen. The following criteria or conditions are assumed for estimating water quality control requirements: (1) removal of 90 percent of the organic substances exerting BOD will be achieved by treatment; (2) treated wastes will be mixed uniformly in receiving waters; (3) dissolved oxygen content will be maintained at 4 ppm or more; and (4) storage and waste releases will, insofar as possible, be arranged to accomplish maximum use of the water resources in the basin.

Municipal Wastes

The community of Mangum is sewered and the wastes receive secondary treatment prior to discharge to Salt Fork. Mangum is a farm community with no major waste-producing industries. Streamflow regulation will be required to maintain satisfactory quality downstream from the Mangum waste discharge.

The city of Altus is sewered and will be served by waste stabilization ponds in early 1963 and treated effluent will be discharged to Bitter Creek, a tributary to the South Fork. No quality control will be needed to maintain stream quality below Altus since large quantities of irrigation return flow and runoff from Turkey Creek watershed provide a suitable flow for assimilation of the adequately treated wastes.

Plan to Maintain Water Quality

Flow regulation for stream quality control will be required in Salt Fork in the reach extending from Mangum's waste discharge point to the confluence of Bitter Creek below Altus. Provision for an annual release of 1,120 acre-feet, averaging 1 mgd, for flow regulation will maintain a suitable level of water quality with respect to dissolved oxygen through the year 2012.

VII. VALUE OF STORAGE FOR WATER QUALITY CONTROL PURPOSES

Method of Evaluation

Senate Document No. 97 (87th Congress, 2nd Session) permits the following method of measuring benefits of storage in Federal reservoirs for water quality control:

> "In situations where no adequate means can be devised to evaluate directly the economic effects of water quality improvement, the cost of achieving the same results by the most likely alternative may be used as an approximation of value."

This alternative cost method was used to evaluate storage for water quality control. An unsatisfactory water quality condition can be avoided in the South Fork of the Red River below Mangum's waste discharge point by preventing release of wastes to the stream or providing a flow capable of assimilating the wastes by streamflow regulation.

Alternative Plans Considered

Several alternative plans could possibly be developed to utilize the treated waste effluent, such as discharge to the proposed Mangum Canal, upstream from the city of Altus waterworks intake, thereby eliminating the need for reservoir storage for water quality control, but potentially damaging a source of public water supply. Another alternative considered was a single-purpose impoundment at the project site. This, however, would be too costly. Therefore, from the standpoint of aesthetics, pollution abatement, and economy, there appears to be but one effective alternative.

The most feasible alternative means of water quality control would be provision of a holding lagoon for Mangum's treated wastes with ample storage to permit percolation and evaporation to preclude the need for discharge.

A lagoon consisting of two 50-acre cells (water depth between 3 and 5 feet) would cost approximately $61,000 to construct, including land and engineering fees. Annual cost would amount to $1,000 for maintenance and $2,800 for amortization at 4 percent per annum for 50 years. On this basis, the annual benefit of water quality control in the South Fork from Mangum to Altus would be $3,800.

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